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# Application of CBL Combined with PBL in Teaching Tumor Bioinformatics

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**Abstract:**

*Objective:* To explore the application effect of case-based learning (CBL) combined with problem-based learning (PBL) in teaching tumor bioinformatics and evaluate students' satisfaction with this teaching model. *Methods:* A total of 62 four-year students majoring in biomedical engineering from the 2020 grade who took the tumor bioinformatics course at the Air Force Military Medical University were selected and divided into an experimental group and a control group using a random number table method, with 31 students in each group. The experimental group was taught using CBL combined with PBL, while the control group was taught using traditional teaching methods. After the completion of teaching, a propositional examination was conducted to assess the teaching effectiveness, and a questionnaire survey was used to evaluate students' satisfaction with the two teaching models. *Results:* After statistical analysis, the scores of multiple choice questions (24.52 ± 2.69) points, short answer questions (35.21 ± 3.03) points, essay questions (24.28 ± 3.41) points, and total scores (78.15 ± 5.89) points in the experimental group were higher than those in the control group (21.94 ± 3.17) points, (32.85 ± 2.78) points, (22.31 ± 3.89) points, (73.81 ± 6.21) points ($P < 0.05$). The students in the experimental group showed higher satisfaction in eight dimensions, including improving enthusiasm for theoretical knowledge learning, enhancing clinical transformation thinking, improving mastery of theoretical knowledge, expanding knowledge of oncology, improving ability to solve clinical problems, enhancing self-directed learning ability, improving efficiency of literature search, and enhancing cooperative learning ability, compared with the control group ($P < 0.05$). *Conclusion:* The combination of CBL and PBL has achieved good results in teaching tumor bioinformatics, improving students' learning ability and knowledge mastery. Students have a high level of satisfaction with this teaching model.

**Keywords:**

Case-based learning
Problem-based learning
Oncology teaching
Bioinformatics

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# 1. Introduction

The problem-based learning (PBL) model is a student-centered approach that integrates problems into theoretical learning, enabling students to more specifically identify learning objectives and grasp key points. PBL courses are typically conducted in small groups, consisting of approximately 5 to 10 students and a faculty tutor. The tutor is responsible for posing problems and guiding students through the process of self-directed learning and problem-solving, rather than providing traditional rote instruction. This teaching model represents a shift from traditional lecture-based methods to student-centered approaches, theoretically putting the initiative in students' hands to construct their learning plans and customize their learning processes. Case-based learning (CBL), derived from PBL, is more commonly applied in medical education. The classic CBL model is widely used in clinical rounds and case discussions. It typically uses clinical cases or medical diagnosis and treatment difficulties as backgrounds, with the latest clinical diagnosis and treatment plans as entry points, to immerse students in real-case scenarios and improve their mastery and application of basic theoretical knowledge.

Bioinformatics is a classic interdisciplinary subject that combines medicine and engineering. Its essence lies in utilizing big data resources on the internet technology platform to solve biological and medical problems, making it an extremely important and significant research tool in oncology research. With the initial completion of the Human Genome Project and the deepening of oncology research, researchers can extract data from established tumor bioinformatics databases using computers and conduct systematic, efficient, and deep-level analyses to scientifically predict and conduct translational research on possible processes and molecular pathways in tumor development. In recent years, many medical schools have also offered medically related bioinformatics courses. However, the promotion and implementation of tumor bioinformatics teaching models in China are still in the exploratory stage, and there is an urgent need to establish a suitable teaching model for medical schools. Therefore, in tumor bioinformatics teaching, ways to apply the CBL combined with the PBL teaching model is compensating for the deficiencies of traditional teaching models, enhancing students' interest in learning and self-learning abilities, and thereby improving course teaching effectiveness has become a primary teaching research and reform objective.

# 2. Subjects and methods

## 2.1. Subjects

Sixty-two 2020-level biomedical engineering students taking the tumor bioinformatics course at the Air Force Military Medical University were selected and randomly divided into an experimental group and a control group using a random number table, with 31 students in each group. The experimental group was taught using CBL combined with PBL, while the control group was taught using traditional teaching methods. In the experimental group, there were 25 males and 6 females, with an average age of (20.88 ± 1.12) years and an average final score of the previous semester of (82.5 ± 8.3) points. In the control group, there were 27 males and 4 females, with an average age of (20.22 ± 1.78) years and an average final score of the previous semester of (83.2 ± 7.9) points. There were no statistically significant differences in basic information (gender, age, final score of the previous semester) between the two groups ($P > 0.05$). Both groups were taught by the same instructor.

## 2.2. Teaching materials and lesson plans

All teaching content was completed according to the teaching syllabus and teaching plan. There were no differences in the total number of teaching hours, total teaching content, and teacher workload between the two teaching models (experimental and control groups). The textbooks used were "Bioinformatics" (Science Press, 3rd edition, edited by Chen Ming) and "Medical Bioinformatics - Cases and Practices" (Tsinghua University Press, edited by Hua Lin and Li Lin).

## 2.3. Teaching methods for the control group

Students in the control group were taught using the traditional teaching model, primarily through teacher lectures, where the teacher was the primary leader of learning. The teacher explained the basic theories and general analysis methods of tumor bioinformatics in the classroom, mainly including an introduction to tumor bioinformatics, the NCBI nucleic acid database, the

PDB protein structure database, the protein interaction STRING database, the protein expression database Human Protein Atlas, the TCGA tumor mutation database, the comprehensive tumor analysis database GEPIA, and other learning content.

### 2.4. Teaching methods for the experimental group

Students in the experimental group were taught using a combination of CBL and PBL teaching models. They were divided into discussion groups of 5–6 students, with each group having a group leader. The teaching content was divided into three stages: pre-class preparation, group discussion, and centralized discussion and summary.

(1) Pre-class preparation (presenting cases, CBL): The teacher developed teaching strategies based on the course outline, carefully selected case materials, and presented cases that were close to the clinical reality of oncology and could be solved using bioinformatics methods (such as screening prognostic markers for breast cancer subtype-related tumors and predicting their prognostic effects). Additionally, the teacher followed the research frontier and selected hot topics in oncology research, proposing practical cases that could be solved through bioinformatics methods (such as screening differentially expressed genes in glioma stem cells and predicting interacting molecules), which were then assigned to each group.

(2) Group discussion (problem-oriented, PBL): Firstly, the teacher guided the students to break down the cases into several problems, each requiring analysis using different bioinformatics tools. Then, the group members conducted literature reviews, data collection, and data analysis according to their assignments. Finally, they discussed and analyzed the results within the group and summarized the unsolvable problems.

(3) Centralized discussion and summary: During the classroom session, representatives from each group presented their solutions to the initial case problems and the difficulties they encountered, which were then complemented or corrected by other students. Full discussions were conducted among the groups. After the group discussions, the teacher summarized the key points of the case knowledge and emphasized the important and difficult points of the lesson. For unsolvable problems encountered during the case-solving process, the teacher provided inspiration, hints, and guidance. Finally, each group reorganized their case solutions and submitted a written analysis report, summarizing the insights and reflections gained during the case-solving process.

### 2.5. Teaching effectiveness and model evaluation

At the end of the course, students took a written examination focusing on two aspects: basic knowledge of tumor bioinformatics and analytical methods. The exam included multiple-choice questions, short-answer questions, and essay questions, with a total score of 100 points. Additionally, a questionnaire survey was conducted to compare the satisfaction levels of the two groups during the teaching process. The questionnaire mainly covered eight dimensions, whether it improved theoretical knowledge learning enthusiasm, clinical transformation thinking, theoretical knowledge mastery, expansion of oncology medical knowledge, ability to solve clinical problems, self-learning ability, literature search efficiency, and cooperative learning ability. Evaluation was based on four levels: very satisfied, relatively satisfied, average, and dissatisfied.

Satisfaction rate = (number of very satisfied + number of relatively satisfied) / total number of students × 100%.

### 2.6. Statistical methods

Data were analyzed using SPSS 19.0 statistical software. Measurement data were expressed as mean ± standard deviation (SD) and comparisons between groups were performed using the independent samples *t*-test. Count data were expressed as cases (%), and comparisons between groups were performed using the chi-square test. $P < 0.05$ was considered statistically significant.

# 3. Results

## 3.1. Evaluation of teaching effectiveness

Examination results showed that the total scores of students in the experimental group were higher than those in the control group. The scores of multiple-choice questions, short-answer questions, and essay questions were all higher in the experimental group than in the control group, with statistically significant differences ($P < 0.05$) (**Table 1**). The experimental group, which adopted CBL combined with PBL teaching methods, achieved better academic performance and learning effects compared to the traditional teaching model used in the control group, making it easier to achieve the expected training goals.

## 3.2. Survey on teaching satisfaction

The questionnaire survey found that students in the experimental group had higher satisfaction levels than those in the control group in all eight dimensions: (1) improving enthusiasm for theoretical knowledge learning, (2) enhancing cultivation of clinical transformation thinking, (3) improving mastery of theoretical knowledge, (4) expanding knowledge of oncology medicine, (5) improving ability to solve clinical problems, (6) enhancing self-learning ability, (7) improving literature search efficiency, and (8) enhancing cooperative learning ability. The differences were statistically significant ($P < 0.05$) (**Table 2**). The results indicate that students have a higher level of acceptance and satisfaction with the CBL combined with the PBL teaching method, making it easier to implement this teaching model.

# 4. Discussion

Bioinformatics is an emerging interdisciplinary field that combines medicine and engineering, characterized by a vast amount of information and rapid knowledge updates [10]. Currently, the application of bioinformatics

**Table 1.** Comparison of examination scores between the two groups (mean ± SD, scores)

| Group | Number of people | Multiple-choice questions | Short-answer questions | Essay questions | Total score |
|---|---|---|---|---|---|
| Control group | 31 | 21.94 ± 3.17 | 32.85 ± 2.78 | 22.31 ± 3.89 | 73.81 ± 6.21 |
| Experimental group | 31 | 24.52 ± 2.69 | 35.21 ± 3.03 | 24.28 ± 3.41 | 78.15 ± 5.89 |
| *t*-value | | 3.452 | 3.101 | 3.312 | 4.101 |
| *p*-value | | 0.001 | 0.008 | 0.011 | 0.006 |

**Table 2.** Survey on teaching satisfaction of two groups of students (number of people, %)

| Group | Number of people | Improving enthusiasm for theoretical knowledge learning | Enhancing the cultivation of clinical transformation thinking | Improving mastery of theoretical knowledge | Expanding knowledge of oncology medicine |
|---|---|---|---|---|---|
| Control group | 31 | 8 (25.81) | 9 (29.03) | 7 (22.58) | 5 (16.13) |
| Experimental group | 31 | 26 (83.87) | 25 (80.05) | 24 (77.42) | 23 (74.19) |
| $\chi^2$-value | | 21.101 | 16.672 | 18.645 | 21.101 |
| *p*-value | | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

| Group | Number of people | Improving ability to solve clinical problems | Enhancing self-learning ability | Improving literature search efficiency | Enhancing cooperative learning ability |
|---|---|---|---|---|---|
| Control group | 31 | 11 (35.48) | 2(6.45) | 10 (32.26) | 3 (9.68) |
| Experimental group | 31 | 19 (61.29) | 25(80.65) | 22 (70.97) | 20 (64.52) |
| $\chi^2$-value | | 4.133 | 34.707 | 9.300 | 19.975 |
| *p*-value | | 0.042 | < 0.001 | 0.002 | < 0.001 |

in medicine is primarily focused on oncology research. With the continuous increase in human bioinformatics big data, research on the molecular mechanisms and signaling pathways of tumor development is deepening, and the development of oncology bioinformatics has entered a fast track. High-throughput data information such as the genome, transcriptome, translatome, proteome, epigenome, and metabolome of tumors is experiencing explosive growth [10]. It is difficult to uncover general patterns in the vast knowledge base of oncology solely through traditional experiments and literature reviews. Therefore, bioinformatics methods must be employed to extract and analyze effective information from massive big data.

The development of bioinformatics in China started late, and the teaching models in various higher education institutions, especially medical schools, are still in the initial exploration stage. Currently, medical schools mainly follow the traditional teaching model of "focusing on classroom teaching, with teacher instruction and theoretical teaching as the mainstay" for bioinformatics teaching [11]. In theoretical classrooms, passive teaching methods such as "indoctrination" and "duck-filling" predominate, while in practical teaching classrooms, teachers mainly lecture on bioinformatics processing procedures, with limited exploration and establishment of autonomous and heuristic teaching models. Some institutions define bioinformatics practical courses as literature search courses [12]. The relatively uniform teaching models among medical schools prevent students from acquiring relevant theoretical knowledge and practical skills in the current era of big data in biology. This situation stands in contrast to the urgent need for oncology bioinformatics talents in the country, becoming an increasingly prominent contradiction.

After three years of teaching reform and exploration, the Department of Pathology at the School of Basic Medical Sciences, Air Force Military Medical University, innovatively combined the CBL and PBL teaching models and applied them to the teaching process of oncology bioinformatics. This approach aims to stimulate medical students' interest and enthusiasm in learning oncology bioinformatics, improve teaching effectiveness and student acceptance, and cultivate innovative oncology bioinformatics talents.

The PBL teaching model is a problem-oriented and student-centered approach that employs various teaching methods such as problem-based, heuristic, and discussion-based techniques. It integrates knowledge cultivation, ability development, and comprehensive quality training, effectively enhancing students' abilities to analyze and solve problems [13]. The CBL teaching model has a clear teaching objective. Selecting typical practical cases strengthens students' understanding of basic knowledge and concepts through thinking, analyzing, and discussing the cases. Simultaneously, it cultivates students' skills in analyzing and solving practical problems [14].

In the context of oncology bioinformatics teaching, the cases and problems proposed in the CBL and PBL teaching process must be highly targeted, widely applicable, practical, and implementable. On the other hand, the cases and problems must closely align with the teaching syllabus and plan, guiding students to master the key points and difficulties of the course while solving practical problems. For example, the case of "screening prognostic markers for breast cancer subtype-related tumors and predicting their prognostic effects" starts from a clinically relevant and widely applicable issue in breast cancer. It utilizes various bioinformatics methods (such as the TCGA tumor mutation database and the comprehensive tumor analysis database GEPIA) to screen tumor prognostic markers and analyze their prognostic value, emphasizing practicality and implementability. The problems raised by this case (such as how to classify breast cancer, how to screen tumor prognostic markers, and how to analyze prognostic predictions) closely align with the teaching syllabus and plan, highlighting the importance of guiding students to master the key points and difficulties of the course. This approach achieves a teaching effect that is both efficient and effective.

In this study, the CBL combined with the PBL teaching model was applied to the teaching of oncology bioinformatics, yielding positive teaching results. These findings are highly consistent with the application of this teaching model in other disciplines [15,16]. The results of this study show that students who used the CBL combined with the PBL teaching model achieved significantly higher exam scores and teaching satisfaction compared to the traditional teaching group. The use of CBL combined with PBL improved students' theoretical exam scores and more importantly, stimulated their enthusiasm for learning oncology bioinformatics. It enhanced their abilities in autonomous learning, collaborative learning, cultivating translational medical thinking, and solving practical problems.

The PBL (Problem-Based Learning) teaching method requires students to master relevant professional knowledge and the ability to analyze specific problems. It mobilizes students' initiative and enthusiasm for learning, encouraging them to actively invest time and energy in their studies. Through group discussions, students can leverage their strengths and improve upon their weaknesses, ultimately applying the knowledge they have learned to solve practical problems.

The CBL (Case-Based Learning) teaching method closely follows current research frontiers and hotspots. It utilizes bioinformatics techniques to process and analyze specific cases of tumor research, predicting directional and possible issues in tumor research and exploring clinically valuable molecular mechanisms and signaling pathways. The PBL and CBL teaching methods complement each other, forming a targeted, interactive, and practical teaching process.

The CBL combined with the PBL teaching model is dominated by real-life cases, guiding students to dismantle cases and raise questions. Combined with group discussions, it cultivates students' ability to solve problems collaboratively. Coupled with the teacher's inspiring and guiding teaching methods during the centralized summary process, students can truly improve their ability to analyze and solve practical problems. Therefore, students have a high level of satisfaction with this teaching model.

During the teaching practice, this study found that the CBL combined with the PBL teaching model still has some shortcomings:

(1) Teachers still need to improve their abilities in designing typical cases and problems, grasping the frontiers and hotspots of oncology, and inspiring and guiding students during the teaching process. It is imperative to enhance teachers' mastery of this teaching model in the future.

(2) Students are not yet fully adapted to this teaching model. Some students prefer the traditional lecture-based teaching model, are not active in group discussions, and have low efficiency in searching for materials and literature, leading to unsatisfactory learning results. In the future, students should be gradually guided and encouraged to accept and adapt to this teaching model.

(3) The current theoretical assessment mechanism still does not fully reflect the teaching effectiveness of the CBL combined with the PBL model. In the future, a comprehensive evaluation method combining formative assessment and process assessment can be adopted to evaluate students, better reflecting the teaching effectiveness of comprehensive ability cultivation.

In summary, although the CBL combined with the PBL teaching model still faces some difficulties and shortcomings in oncology bioinformatics teaching, compared with the traditional lecture method, this new teaching model enables students to fully exert their subjective initiative, improve their ability to solve practical problems and achieve better teaching results. It has distinct advantages. Therefore, in the future teaching of oncology bioinformatics, the CBL combined with the PBL teaching model can better adapt to the development needs of bioinformatics today and has important practical significance for cultivating innovative medical talents.

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**Disclosure statement**

The authors declare no conflict of interest.

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